SUMMER INTERNSHIP REPORT

Introduction to advanced manufacturing processes and extraction of essential oil using steam distillation unit

SUBMITTED BY

SIDDHANT DEY
B. Tech 6th semester (appeared)
Regd. No.: HRD/STU.TRG/ST/23/003
Period of training: 08/06/2023 to 14/07/2023
Department of Mechanical Engineering
Tezpur University, Napaam, Tezpur

UNDER THE GUIDANCE OF

Mr. Dhanjit Das
Scientist, General Engineering Division, ESTD
North-East Institute of Science and Technology, Jorhat

CERTIFICATE

This is to certify that the report entitled "**Introduction to advanced manufacturing processes**" *by* ***Siddhant Dey (Regd. No.: HRD/STU.TRG/ST/23/003),*** submitted in the Department of Mechanical Engineering at NEIST, Jorhat, during the summer internship 2023, in partial fulfillment of the requirements for the Degree of Bachelor of Technology in Mechanical Engineering, is carried out under our guidance and supervision. The work contained in this report has not been submitted elsewhere for a Degree/Diploma/Certificate.

(Project Supervisor)

Mr. Dhanjit Das
Scientist
NEIST, Jorhat

ACKNOWLEDGMENT

We would like to express our appreciation to everyone who played a part in the successful completion of this project.

Firstly, we are deeply grateful to our project supervisor, **Mr. Dhanjit Das**, for his invaluable guidance, support, and motivation throughout the project. His expertise and recommendations have been crucial in shaping my ideas and ensuring that my research is of the highest quality. We feel fortunate to have had the opportunity to work under his supervision. Furthermore, we would like to thank the H.O.D of Mechanical Engineering, **Er. Jayanta Jyoti Bora**, for giving us the opportunity to work on an important and relevant topic like **"Introduction to advanced manufacturing processes"**. This topic has allowed us to explore sustainable architecture in greater depth and discover innovative solutions for more efficient manufacturing processes.

We are grateful to our parents, who have been a constant source of encouragement, support, and inspiration for us. Their unwavering faith in us has been a driving force behind our success.

Finally, we would like to express our thanks to our friends and colleagues, whose assistance and feedback have been instrumental in overcoming the challenges and obstacles we encountered during our project.

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Siddhant Dey (Regd. No.: HRD/STU.TRG/ST/23/003)

ABSTRACT

The summer internship report encompasses three distinct areas: CNC machining, universal testing machine (UTM), and the extraction of essential oil using steam distillation. The main objectives of the internship were to gain practical knowledge and hands-on experience in these fields, understand their underlying principles, and explore their applications in different industries.

The report begins by introducing CNC machining and its significance in modern manufacturing processes. It discusses the various types of CNC machines, their capabilities, and the advantages they offer in terms of precision, efficiency, and automation. The internship involved practical training sessions on CNC machine operation, programming, tool selection, and quality control measures.

The second part of the internship focused on the universal testing machine (UTM) and its role in evaluating the mechanical properties of materials. The report highlights the importance of UTM in engineering, research, and quality control applications. The internship involved conducting tests using the UTM, such as tensile, compression, and flexural tests, to understand material behaviour, strength, and deformation characteristics.

The third area of the internship was centred around the extraction of essential oil using steam distillation. The report explores the principles and techniques of steam distillation as a method for extracting essential oils from plant materials. Practical sessions were conducted to set up and operate a steam distillation apparatus and monitor the process parameters.

In conclusion, the summer internship provided valuable practical knowledge and experience in CNC machining, universal testing machine operation, and steam distillation for essential oil extraction. The internship contributed to a better understanding of these fields, their applications, and the factors influencing their outcomes.

CONTENTS

1. Introduction

1.1 Welding

Welding can be defined as the process of joining two similar or dissimilar metallic components with the application of heat, with or without the application of pressure and with or without the use of filler metal. [1]

1.1.1 Classification of welding

1. Fusion welding (non-pressure welding):

a) Arc welding.
b) Gas welding.
c) Thermit welding
d) Laser beam welding.
e) Electron-beam welding.

2. Pressure welding:

a) Resistance welding
b) Friction welding
c) Forge welding
d) Diffusion welding.
e) Arc pressure welding.

1.1.2 Gas Metal Arc welding (GMAW) / Metal Inert Gas welding (MIG)

This process is based on the principle of developing weld by melting faying surfaces of the base metal using heat produced by a welding arc established between base metal and a consumable electrode. Welding arc and weld pool are well protected by a jet of shielding inactive gas coming out of the nozzle and forming a shroud around the arc and weld. Metal inert gas process is similar to TIG welding except that it uses the automatically fed consumable electrode therefore it offers high deposition rate and so it suits for good quality weld joints required for industrial fabrication. [2]

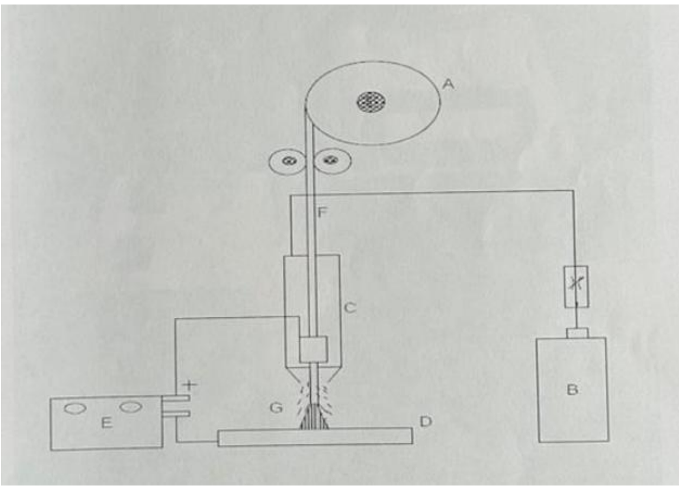

Figure 1: Schematic diagram of GMAW/MIG welding [3]

Depending upon the electrode diameter, material and electrode extension required. Welding may use either constant voltage or constant current type of the welding power source. For small diameter electrodes (< 2.4 mm) when electrical resistive heating controls the melting rate predominantly; constant voltage power source (DCEP) is used to take advantage of the self-regulating arc whereas in case of large diameter electrode constant current power source is used with variable speed electrode feed drive system to maintain the arc length.

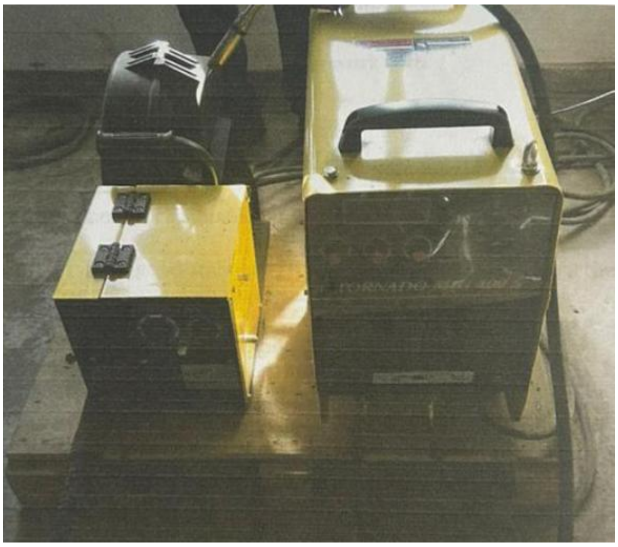

Figure 2: Showing power source of MIG welding

1.1.3 **Gas welding (Oxy-Acetylene gas welding)**

In gas welding, heat is generated by the combustion reaction between fuel gas and oxygen. Oxy-Acetylene welding is a type of gas welding in which acetylene (C_2H_2) is used as the fuel gas. Here burning of acetylene with the help of oxygen forms a concentrated flame of high temperature. This flame directly strikes the weld area and melts the weld surface and filler material. The melted parts of welding plates diffused in one another and create a weld joint after cooling. This welding method can be used to join most of common metals used in daily life.[4]

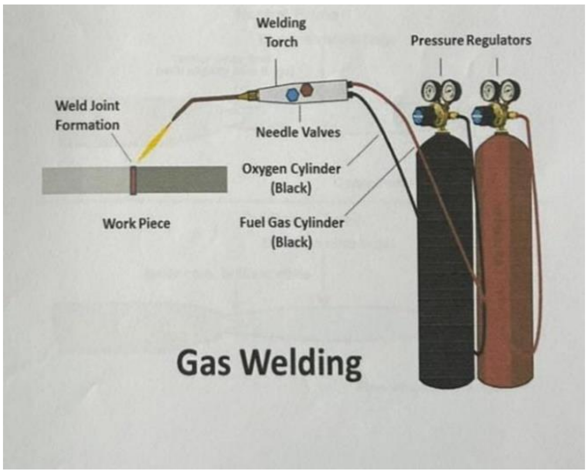

Figure 3: Gas welding setup [5]

Reaction involved in gas welding

1st Stage:

$C_2H_2+O_2 \rightarrow 2CO+H_2+Heat$

2nd Stage:

$2CO+ O_2 \rightarrow 2CO_2+Heat$

3rd Stage:

$H_2+ O_2 \rightarrow 2\ H_2O+ Heat$

Types of flames in oxy-acetylene welding[6]:
Neutral Flame:
The ratio of oxygen to acetylene is 1:1, all reactions are carried to completion and a neutral flame is produced. Most welding is done with a neutral flame. It is chemically neutral and neither oxidizes or carburizes the metal being welded. The flame temperature is around 3100°C. Neutral flame is commonly used to weld mild steel, cast iron, stainless steel.
Oxidising Flame:
Oxidizing Flame contains more oxygen than acetylene. Temperature of the flame is around 3600 °C. It is used to weld copper and copper alloys but harmful when welding steel because the excess oxygen react with carbon decarburizing the region around the weld.
Carburizing flame:
The flame contains more acetylene than oxygen. Temperature of the flame is around 2900°C. It is also called Carburizing Flame due to its tendency to introduce carbon into the molten metal.

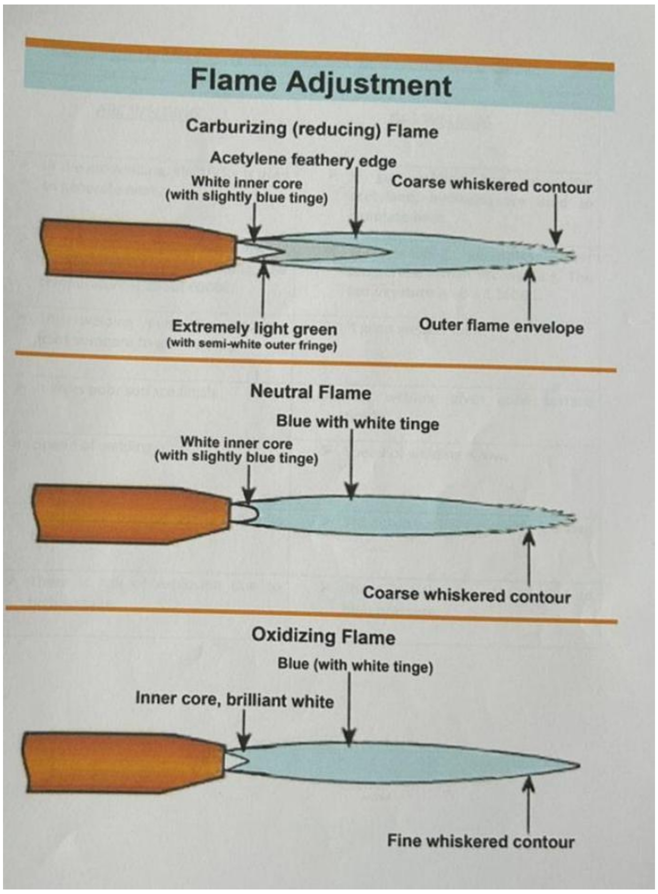

Figure 4: Types of oxy-acetylene flames [6]

The components of oxy-acetylene gas include
a. Welding Torch
b. Pressure Regulators
c. Needle Valves
d. Oxygen Cylinder
e. Fuel Gas Cylinder

1.1.4 **Plasma arc cutting**

Plasma arc cutting is a widely used thermal cutting process that utilizes a high-velocity jet of ionized gas, known as plasma, to cut through electrically conductive materials. It is particularly effective for cutting metals such as steel, stainless steel, aluminium, and copper, offering advantages over other cutting methods in terms of speed, precision, and versatility. The process begins by passing a high-temperature gas, typically compressed air or a gas mixture, through a small nozzle. An electric arc is then formed between an electrode and the workpiece, causing the gas to be heated and ionized, transforming it into plasma. The plasma, reaching temperatures of up to 30,000 degrees Fahrenheit, creates a focused and intense heat source capable of melting through the metal. As the plasma jet is directed towards the workpiece, it rapidly heats and melts the material. Simultaneously, a high-velocity gas flow blows away the molten metal, effectively cutting through the material. The nozzle's design and the selection of gases can influence the quality and characteristics of the cut, allowing for adjustments to achieve desired results. Plasma arc cutting offers several advantages. Firstly, it is a highly efficient process, allowing for fast cutting speeds, which significantly reduces production time. Additionally, it provides excellent cut quality with narrow kerf widths, minimal heat-affected zones, and smooth, clean edges. The versatility of plasma cutting allows for cutting through a wide range of material thicknesses, making it suitable for various applications across industries such as manufacturing, automotive, shipbuilding, and construction.

However, it's important to note that plasma arc cutting has limitations. It is typically limited to electrically conductive materials and may not be as effective for non-metallic materials. The process also produces intense heat and UV radiation, requiring appropriate safety measures and protective equipment. [7]

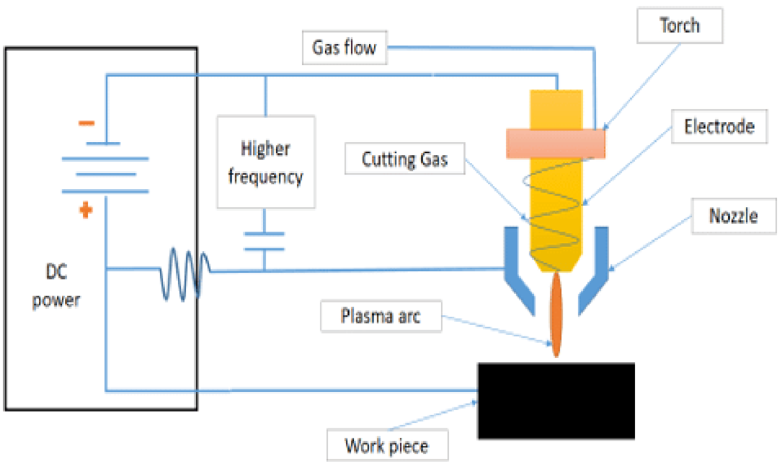

Figure 5: Schematic diagram of plasma arc cutting machine [8]

1.1.5 **Welding defects**

Welding defects are imperfections that occur during the welding process, leading to substandard welds. These defects compromise the integrity and strength of the weld joint, potentially causing structural failures or reduced performance. To ensure high-quality welds, proper welding procedures, techniques, cleanliness, and adherence to specified parameters are crucial. Regular inspection and testing methods help identify and address welding defects, ensuring the welds meet the required standards for safety and performance.

Some common welding defects include: [9]

1. Porosity: Porosity is the presence of small gas pockets within the weld metal. It can be caused by contaminants, improper shielding gas, inadequate gas flow, or incorrect

welding parameters. Porosity weakens the weld by creating voids, reducing its load-carrying capacity.

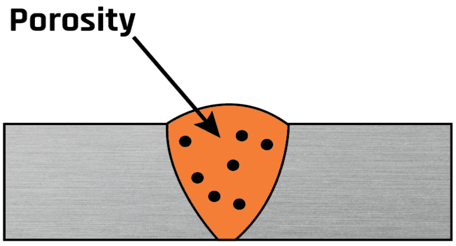

Figure 6: Porosity [10]

2. Incomplete penetration: Incomplete penetration occurs when the weld metal does not fully penetrate the joint or reach the root. It can be caused by insufficient heat input, improper joint preparation, or improper welding technique. Incomplete penetration reduces the strength and load-bearing capacity of the weld joint.

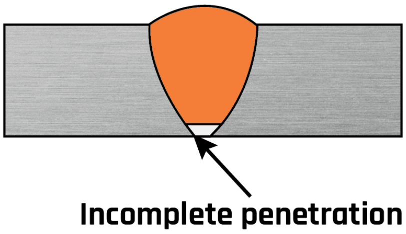

Figure 7: Incomplete penetration [10]

3. Lack of fusion: Lack of fusion happens when the weld metal fails to fuse adequately with the base metal or previously deposited weld metal. It can occur due to insufficient heat input, improper welding technique, or contamination on the base metal surface. Lack of fusion weakens the weld joint and can lead to premature failure.

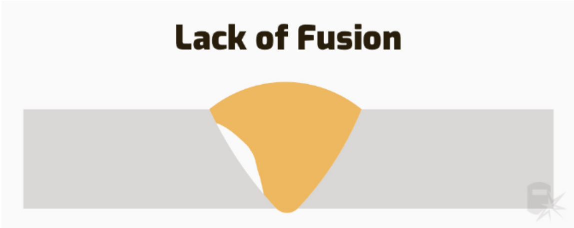

Figure 8: Lack of fusion [11]

4. Undercutting: Undercutting is the groove or depression formed along the edges of the weld joint. It typically occurs due to excessive heat input or improper welding technique. Undercutting reduces the effective cross-sectional area of the weld, leading to stress concentration and potential cracking.

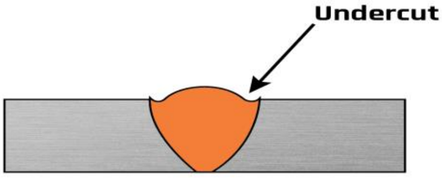

Figure 9: Undercut [10]

5. Spatter: Spatter refers to the expulsion of molten metal during the welding process, leaving unwanted droplets or splatters on the weld surface. It can be caused by improper shielding gas, incorrect wire feed speed, or welding parameters. Excessive spatter affects the weld appearance, and the splatters can act as stress raisers.

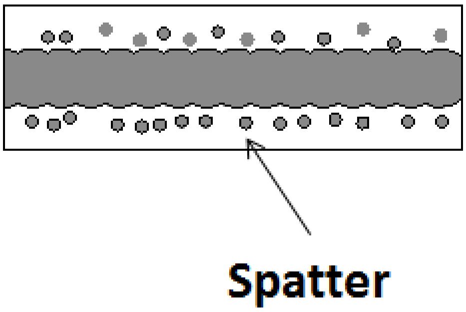

Figure 10: Spatter [12]

6. Cracking: Weld cracking can occur in various forms, such as hot cracks, cold cracks, or stress cracks. It can result from factors like high cooling rates, residual stresses, inadequate preheating, or improper material selection. Cracks severely compromise the integrity of the weld joint and can lead to catastrophic failure.

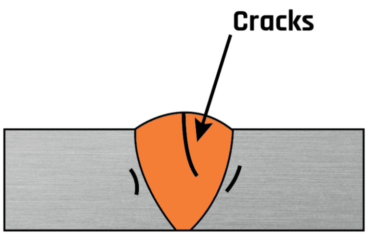

Figure 11: Cracking [10]

7. Distortion: Weld distortion refers to the unwanted changes in the shape or dimensions of the welded structure due to the heating and cooling cycles during welding. It can occur due to inadequate fixturing, welding sequence, or improper welding parameters. Distortion can affect the fit and functionality of the welded components.

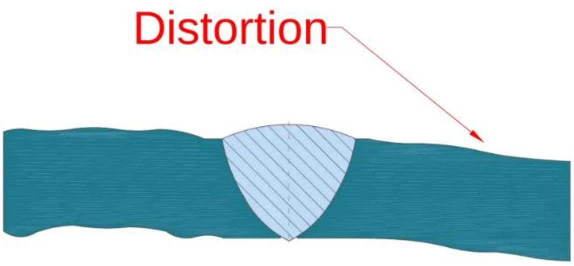

Figure 12: Distortion [13]

1.2 **CNC machining**

CNC machining refers to the process of using computer numerical control (CNC) technology to automate the operation of machine tools. It involves the use of computerized controls and programming to precisely control the movement and operation of machining equipment, such as mills, lathes, routers, grinders, and other tools. This process is suitable for a wide range of materials, including metals, plastics, wood, glass, foam, and composites, and finds application in a variety of industries, such as large CNC machining, machining of parts and prototypes for telecommunications, and CNC machining aerospace parts, which require tighter tolerances than other industries. [14]

1.2.1 **CNC machine programming**

When the CNC system is activated, the software is programmed with the desired cuts, and the corresponding tools and machinery receive the instructions to carry out the specified dimensional tasks, similar to the functioning of a robot.

In CNC programming, the code generator within the numerical system often assumes the perfection of the mechanisms, disregarding the possibility of errors. However, the probability of errors increases when the CNC machine is directed to cut in multiple directions simultaneously. The arrangement of a tool in a numerical control system is outlined through a series of inputs known as the part program. [14]

The language utilized in CNC machining, known as G-code and M-code, is written to govern various machine behaviours, including speed, feed rate, and coordination. In the CNC machining process, a 2D or 3D CAD drawing is created, and this drawing is subsequently translated into computer code for execution by the CNC system.

G Codes

CODE	FUNCTION
G00	Rapid Positioning Motion (X,Y,Z,A,B)
G01	Linear Interpolation Motion (X ,Y,Z,A,B, F)
G02	Circular Interpolation Motion CW (X,Y,Z,A, I, J,K,R,F)
G03	Circular Interpolation Motion CCW (X,Y,Z,A, I, J,K,R,F)
G04	Dwell (P) (P=Seconds″.” Milliseconds)
G17	Circular Motion XY Plane Selection (G02 or G03)
G18	Circular Motion ZX Plane Selection (G02 or G03)
G19	Circular Motion YZ Plane Selection (G02 or G03)
G20	Inch Coordinate Positioning
G21	Metric Coordinate Positioning
G28	Machine Zero Return Thru Ref. Point (X,Y,Z,A,B)
G29	Move to Location Through G28 Ref. Point (X ,Y,Z,A,B)
G40	Cutter Comp Cancel G41/G42/G141 (X ,Y)
G41	2D Cutter Compensation, Left (X ,Y,D)
G42	2D Cutter Compensation, Right (X ,Y,D)
G43	Tool Length Compensation + (H,Z)
G49	Tool Length Compensation Cancel G43/G44/G43
G52	Work Offset Positioning Coordinate
G54	Work Offset Positioning Coordinate #1 (Setting 56)
G55	Work Offset Positioning Coordinate #2
G56	Work Offset Positioning Coordinate #3
G57	Work Offset Positioning Coordinate #4
G58	Work Offset Positioning Coordinate #5

G59	Work Offset Positioning Coordinate #6
G76	Fine Boring Canned Cycle (X,Y,A,B,Z,I,J,P,Q,R,L,F)
G80	Cancel Canned Cycle (Setting 56)
G81	Drill Canned Cycle (X ,Y,A,B,Z,R, L ,F)
G82	Spot Drill / Counterbore Canned Cycle (X,Y,A,B,Z,P,R, L, F)
G85	Bore In ~ Bore Out Canned Cycle (X ,Y,A,B,Z,R, L ,F)
G86	Bore In ~ Stop ~ Rapid Out Canned Cycle (X ,Y,A,B,Z,R, L, F)
G87	Bore In ~ Manual Retract Canned Cycle (X,Y,A,B,Z,R,L,F)
G89	Bore In ~ Dwell ~ Bore Out Canned Cycle (X,Y,A,B,Z,P,R,L,F)
G90	Absolute Positioning Command
G91	Incremental Positioning Command
G92	Global Work Coordinate System
G93	Inverse Time Feed Mode ON
G94	Inverse Time Feed OFF / Feed Per Minute ON
G97	Spindle Speed in RPM
G98	Canned Cycle Initial Point Return

M Codes

Code	Function
M00	Program Stop
M01	Optional Program Stop
M02	Program End
M03	Spindle ON Clockwise
M04	Spindle ON Counterclockwise
M05	Spindle Stop
M06	Tool Change (T)
M08	Coolant ON
M09	Coolant OFF
M30	Program End and Reset
M31	Chip Auger Forward
M33	Chip Auger Stop
M34	Coolant Spigot Position Down, Increment
M35	Coolant Spigot Position Up, Decrement
M36	Pallet Part Ready
M41	Spindle Low Gear Override
M42	Spindle High Gear Override
M50	Execute Pallet Change
M83	Auto Air Jet ON
M84	Auto Air Jet OFF
M88	Coolant Through Spindle ON
M99	Routine Return of Loop

1.2.2 **Types of CNC machining processes**

The most common mechanical CNC machining operations include

1.2.2.1 **CNC milling**

Milling is a machining technique that utilizes rotating cutting tools with multiple points to eliminate material from the workpiece. In CNC milling, the workpiece is usually fed to the cutting tool in the same direction as its rotation, whereas in manual milling, the workpiece is fed in the opposite direction to the tool's rotation. The milling process offers various operational capabilities, including face milling, which involves cutting shallow, flat surfaces and flat-bottomed cavities on the workpiece, and peripheral milling, which involves cutting deep cavities such as slots and threads into the workpiece. [15]

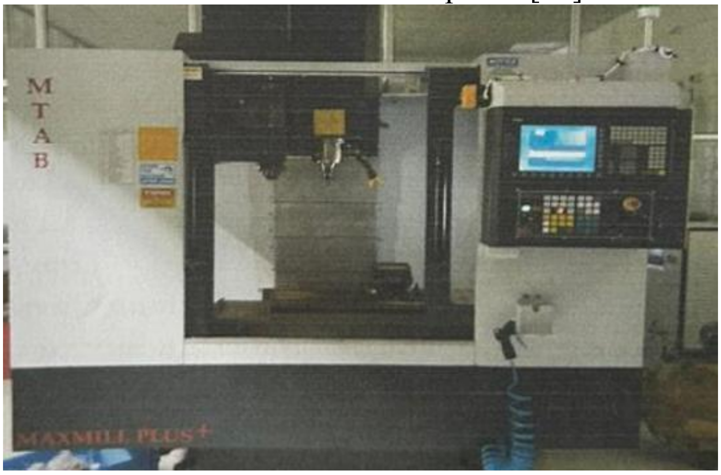

Figure 13: CNC milling machine with ATC (Automatic Tool Change)

1.2.2.2 **CNC turning**

Turning is a machining technique that utilizes cutting tools with a single point to eliminate material from a rotating workpiece. In CNC turning, the cutting tool is linearly fed along the surface of the rotating workpiece, usually on a CNC lathe machine. This process involves removing material around the circumference of the workpiece until the desired diameter is achieved, resulting in the production of cylindrical parts with both external and internal features such as slots, tapers, and threads. The turning process offers various operational capabilities, including boring, facing, grooving, and thread cutting. [15]

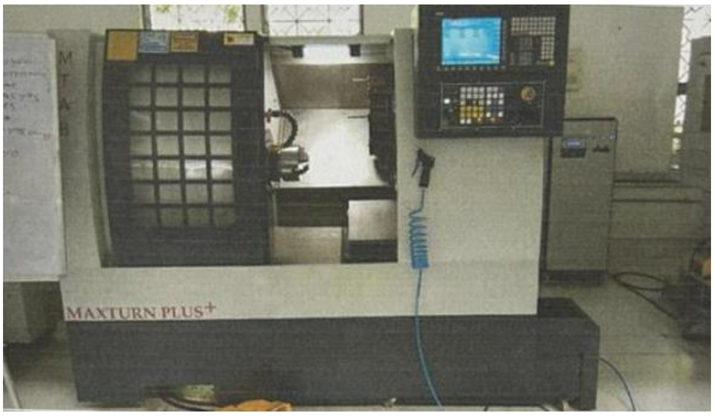

Figure 14: CNC lathe machine with ATC (Automatic Tool Change)

1.3 **Universal Testing Machine**

A Universal Testing Machine (UTM) is a highly versatile mechanical testing instrument used to evaluate the mechanical properties of various materials. It is an essential tool in materials testing laboratories, research facilities, quality control departments, and educational institutions.

It is designed to apply controlled forces and deformations to test specimens, allowing for the measurement and analysis of their mechanical behaviour. The machine can perform a wide range of tests, including tensile, compression, flexural, shear, and cyclic tests.

The core components of a UTM include a load frame, actuator, load cell, grips or fixtures, control system, and software for data acquisition and analysis. The load frame provides the structural integrity of the machine, while the actuator generates the force required for deformation. The load cell converts the applied force into an electrical signal, which is used to measure and record the load accurately.

Grips or fixtures are used to securely hold the test specimen during the test, ensuring proper alignment and preventing slippage. They are designed to accommodate various types and sizes of specimens based on the specific test requirements.

The control system of a UTM enables precise control over testing parameters such as force, displacement, and strain rate. It allows users to set up test configurations, monitor the test in real-time, and control the machine according to specific testing standards or protocols. Additionally, the software associated with the UTM facilitates data acquisition, analysis, and reporting, enabling users to calculate mechanical properties such as strength, modulus, yield point, elongation, and more.

Safety features are an integral part of UTMs to ensure operator safety and protect the machine. Emergency stop buttons, safety shields, and limit switches are incorporated to prevent overloading and accidents during testing.

UTMs are employed in a wide range of industries, including automotive, aerospace, construction, metals and alloys, plastics, textiles, and biomedical materials. They play a crucial role in material characterization, product development, quality control, and research and development activities. The data obtained from UTM tests helps engineers and scientists make informed decisions regarding material selection, design optimization, and performance evaluation, contributing to the advancement of various industries. [16]

1.4 **Extraction of essential oil through steam distillation process**

Steam distillation is the most commonly used method for extracting essential oils from plants. During this process, pressurized steam is forced through the plant material containing the desired oils. The volatile compounds can be distilled at temperatures lower than their boiling points, preserving the natural qualities of the plant material. [17] Steam distillation is a multistage continuous distillation process where steam is used as a stripping gas to extract the oils. The mixture of hot vapours is collected and condensed to produce a liquid in which the oil and water form two distinct layers. One of these layers is essential oil, which contains oil-soluble compounds, and the other is a hydrolysate or hydrosol, which contains water-soluble components. Hydro steam distillation is carried out when the perfumery plant material is susceptible to direct steam. [18]

2. Practical work

2.1 To make butt joint using shielded metal arc welding (SMAW) as per required dimensions.

Tools required:

a. Flat file
b. Grinding machine
c. Cutting machine
d. SMAW machines and equipment
e. Hand shield
f. Electrodes
g. MS flat plate

Procedure followed:

The mild steel flats to be joined are cleaned by wire brush.

a. The flat pieces are arranged properly providing the gap for full penetration for
b. butt joint.
c. The welding current and voltage are set according to the type of metal to be
d. joined.
e. Strike the arc and make tacks at the both ends to hold the metal pieces
f. together during the welding process
g. The beads are laid along the joint maintaining proper speed and arc length.
h. The welded zone is cleaned.

Figure 15: Job done in workshop

2.2 **CNC milling**

A sample design was prepared in the UNIMAT CNC machine on a acrylic workpiece of dimension 100 mm (L) x 400 mm (B) x 15 mm (D). The code and the final product image are given below

```
G21
G90G00X0Y0Z10
G01Y25
X2
Z-1
X8Y35
X33
X40Y25
X2T25
Z10
X0Y0
X20.5Y30
Z-1
X14Y24
X28
X17.5Y14.5
Z10
X0Y0
M3
```

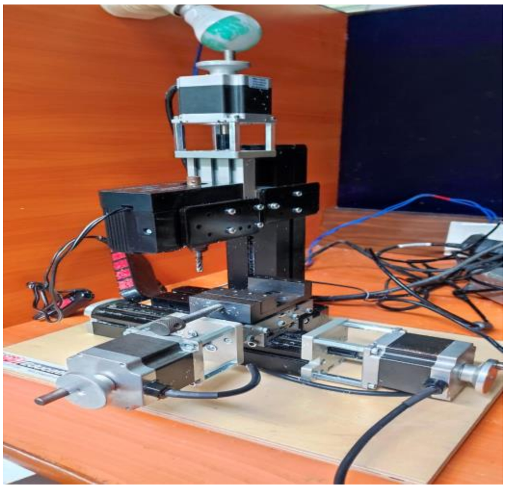

Figure 16: Unimat CNC machine.

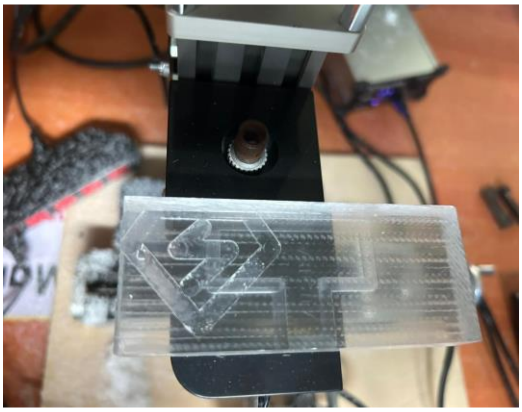

Figure 17: Final product image.

2.3 **CNC turning**

A sample design was prepared in the MTAB XLTURN machine on a mild steel workpiece of dimension 100 mm (L) x 25 mm (D). The code and the final product image are given below

```
G71G94
G75X0Z0
G00X37Z5
CYCLE62("NEIST", 1,,)
CYCLE 952
NEIST","1101311,200,150,3,0.5.1,0.1,0.1,0.1,0,0.125,45,,,,,2,2,,,0,1,0,12,110)
CYCLE 952 NEIST","2101321,150,100,3,02,1,0,0,0,0,0,125,45,,,,,2,2,,,0,1,,0,12,110)
G75X0Z0
M05
M30
NEIST.SPF
G00X0Z0
G01X10
G01Z-2
G02X7Z-7CR=12
G02X127Z-12CR=8
G01X12Z-20
G01X15Z-20
G01X18Z-25
G03X25Z-30CR=8
G01X25Z-35
M17
```

Figure 18: MTAB XLTURN machine

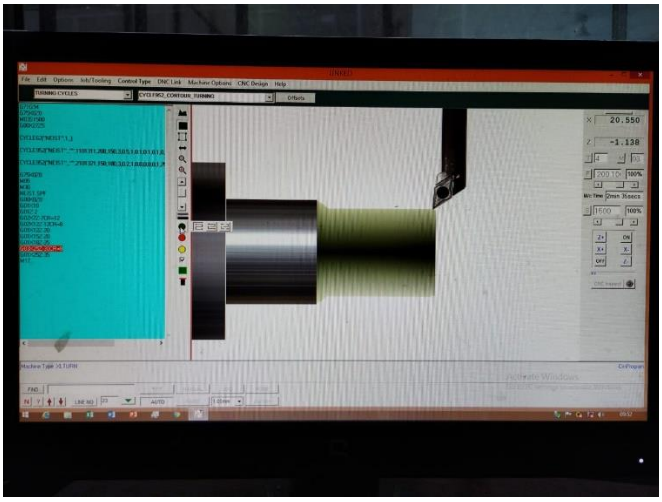

Figure 19: Turning simulation

Figure 20: Final product

2.4 **Universal Testing Machine**

The machine used for this experiment is INSTRON by SATEC SYSTEMS which can provide a maximum tensile force of 10 T. A sample of iron rod of 450 mm length and 12 mm diameter and of material property FE 550 is taken for tensile testing. The testing is done under the parameters mentioned in IS code 1786. The workpiece is fixed in both the upper and bottom jaw with distance of 300 mm in between the faces. The machine is operated on the BLUE HILL operating system when define the material parameters such as sample size and geometry, feedrate that is taken as 0.2 mm/s in this case.

After carrying the following experiment following results are obtained

Yield strength of the rod = 370 MPa

Ultimate tensile stress = 422 MPa

Percentage of elongation = 12.5 %

*It can be noticed that the ultimate tensile stress came out to be 422 MPa but it should be around 550 MPa. This is because beforehand tensile stress has been performed on the same rod sample.

Figure 21: Universal Testing Machine

Figure 22: UTM result interface

2.5 **Steam distillation process for the extraction of tea tree oil**

The essential oil of the Tea Tree has been used for decades, and medical studies have documented its advantages as a beneficial aid in eliminating bacteria, viruses, and fungi. This powerful antiseptic is well known for its ability to treat wounds and for its natural anti-inflammatory properties. [19]

Steam Distillation is used to extract and isolate essential oils from plants for use in natural products. This happens when the steam vaporizes the plant material's volatile compounds, which eventually go through a condensation and collection process.

The entire process of extraction of oil is discussed below [20]

a. Equipment Setup: A steam distillation apparatus, consisting of a distillation flask, a condenser, and a receiving flask. The distillation flask holds the plant material (tea leaves, 250 g), the condenser cools and condenses the steam, and the receiving flask collects the essential oil.

b. Preparation of plant material: The tea leaves containing the desired essential oil is harvested and dried before the extraction process. This helps in concentrating the aromatic compounds and facilitates the release of oils during distillation.

c. Loading the still: The dried plant leaves is placed in a still or a distillation apparatus. The still consists of a heating system, a vessel for holding the leaves, and a condenser for collecting the essential oil.

d. Introduction of steam: Steam is generated in a separate boiler and then introduced into the still. The steam serves two main purposes: it gently heats the leaves, causing the release of essential oil, and it carries the volatile aromatic compounds along with it.

e. Steam passes through the leaves: The steam moves through the leaves, causing the oil glands or resin sacs to rupture and release the essential oil. The steam also helps to break down the cell walls of the leaves, allowing easier access to the aromatic compounds.

f. Vaporization and entrainment: As the steam moves through the leaves, it vaporizes the essential oil and other volatile compounds present. These volatile compounds become entrained within the steam, forming a mixture of steam and oil vapor.

The passing of steam plays a crucial role in the extraction of oil through steam distillation. It aids in the release and volatilization of aromatic compounds present in the plant material, allowing them to be carried along with the steam. Here's a detailed explanation of how the passing of steam facilitates oil extraction:

i. Heat transfer: Steam is generated in a separate boiler and introduced into the still or distillation apparatus. The steam serves as a gentle heat source, warming the plant material. As the temperature increases, the heat energy is transferred to the plant material, causing the essential oil-containing glands or sacs to rupture.
ii. Rupture of oil glands: The application of heat from the steam causes the oil glands within the plant material to rupture. These oil glands contain the essential oil, and when they rupture, the oil is released. The volatile aromatic compounds, which give the essential oil its characteristic fragrance and therapeutic properties, are trapped within these oil glands.
iii. Breaking down cell walls: In addition to rupturing the oil glands, the passing of steam helps break down the cell walls of the plant material. The cell walls act as barriers, hindering the release of the essential oil. By exposing the plant material to steam, the cell walls are softened and ultimately broken down, allowing easier access to the aromatic compounds.
iv. Volatilization and entrainment: As the steam moves through the plant material, it vaporizes the essential oil and other volatile compounds present. These volatile compounds become entrained within the steam, forming a mixture of steam and oil vapor. The steam acts as a carrier, allowing the aromatic compounds to be transported out of the plant material.
v. Steam-oil vapor mixture: The steam, along with the vaporized essential oil and other volatile compounds, exits the still and enters the condenser. At this stage, the mixture is in a gaseous state.

g. Condensation: The steam-oil vapor mixture then enters the condenser, where it is rapidly cooled. The cooling causes the vapor to condense back into liquid form, separating it from the steam. The liquid collected at the end of the condenser is a mixture of water and essential oil.

Condensation is a crucial step in the steam distillation process. After the steam-oil vapor mixture is generated by passing steam through the plant material, it needs to be cooled down and converted back into a liquid state. This transformation is achieved through condensation.

The condensation step involves the following process:

i. Condenser: The steam-oil vapor mixture enters a condenser, which is a cooling apparatus typically consisting of a coiled tube or a series of interconnected tubes. The condenser is usually located at the top of the still or distillation apparatus.
ii. Cooling medium: A cooling medium, such as cold water or chilled air, is circulated around the condenser to lower its temperature. The cooling medium absorbs the heat from the vapor mixture, causing it to lose thermal energy and cool down.
iii. Heat transfer: As the hot vapor mixture passes through the condenser, it comes into contact with the cool surface of the condenser tubes. The temperature difference between the hot vapor and the cool surface facilitates the transfer of heat from the vapor to the condenser.
iv. Conversion to liquid: The heat transfer from the vapor to the condenser causes the vapor to lose energy and undergo a phase change from a gas to a liquid. This phase change is known as condensation. The vapor cools down, loses its kinetic energy, and transitions into liquid droplets.
v. Collection: The liquid droplets, comprising the condensed essential oil and water, accumulate and flow down the condenser tubes. Gravity helps in the collection of the condensed liquid, which is then directed towards a collection vessel or receiver.

h. Separation of oil and water: Since oil and water have different densities, they naturally separate. The collected liquid is transferred to a separation vessel, where the essential oil floats on top of the water due to its lower density. The oil is then carefully separated from the water.

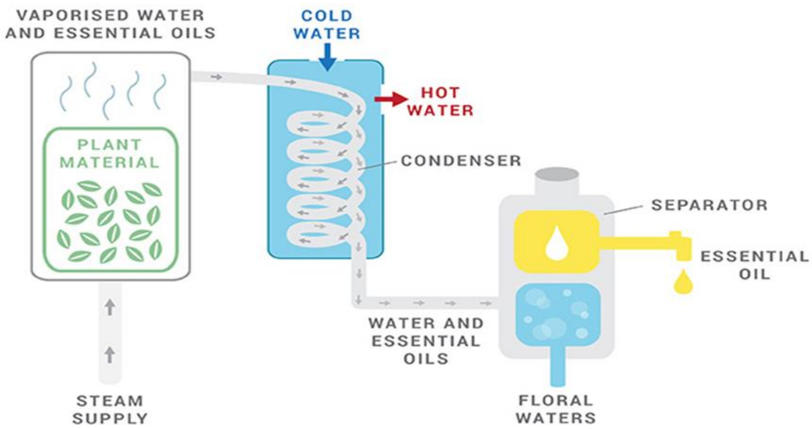

Figure 23: Steam distillation process [21]


Figure 24: Steam distillation unit

3. Conclusion

In conclusion, my summer internship provided me with valuable insights and hands-on experience in the fields of welding, CNC machining, universal testing machine, and the extraction of oil using steam distillation. Throughout the internship, I had the opportunity to work alongside experienced professionals and apply the theoretical knowledge gained during my studies.

During the welding component of the internship, I learned various welding techniques, including MIG, TIG, and arc welding. I gained proficiency in interpreting technical drawings, selecting appropriate welding materials, and operating welding equipment safely. Additionally, I developed a strong understanding of welding principles, such as heat control and material compatibility.

In the CNC machining segment, I acquired practical skills in operating computer numerical control (CNC) machines. I learned how to program the machines, set up workpieces, and utilize various cutting tools for precision machining. This experience enhanced my knowledge of manufacturing processes and allowed me to appreciate the importance of accuracy and attention to detail in the production of complex parts.

Working with the universal testing machine provided me with insights into material testing and characterization. I learned how to conduct mechanical tests such as tensile, compressive, and hardness tests, and gained knowledge of the properties and behaviour of different materials under stress. This experience deepened my understanding of material science and its application in engineering.

Lastly, the extraction of oil using steam distillation taught me about the mechanical processes involved in extracting essential oils from plant materials. I learned the principles of steam distillation, including the proper setup of equipment, temperature control, and collection of distillates. This hands-on experience broadened my knowledge of the processes involved and the utilization of natural resources.

Overall, this summer internship provided me with a comprehensive understanding of welding, CNC machining, universal testing machine operation, and steam distillation for oil extraction. It allowed me to apply my theoretical knowledge to practical situations and develop essential skills relevant to my field of study. I am grateful for the opportunity and confident that the skills and experience gained during this internship will serve as a strong foundation for my future career in engineering.

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